

**What is claimed is:**

1. An electron microscopy system, comprising:
  - a pulsed electron beam source for generating a pulsed primary electron beam incident on a sample;
  - an objective lens disposed in a beam path of secondary electrons emanating from the sample;
  - an electron detector disposed in a beam path of the secondary electrons downstream of the objective lens;
  - a first cavity resonator disposed in the beam path of the secondary electrons downstream of the objective lens and upstream of the electron detector; and
  - a high frequency generator for supplying a high frequency power to the first cavity resonator;  
wherein the first cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the first cavity resonator is a magnetic field oriented transversely to a direction of the beam path of the secondary electrons traversing the first cavity resonator.
2. The electron microscopy system according to claim 1, further comprising a first beam stop having an aperture disposed downstream of the first cavity resonator in the beam path of the secondary electrons.
3. The electron microscopy system according to claim 2, further comprising a controller configured to change a phase of the high frequency power supplied by the high

frequency generator relative to a pulse generation cycle of the pulsed electron beam source.

4. The electron microscopy system according to claim 1, wherein the electron detector is a position sensitive detector configured to detect electron intensities in dependence of a location in a plane oriented transversely with respect to the beam path of the secondary electrons.
5. The electron microscopy system according to claim 1, wherein the first cavity resonator and the high frequency generator are configured such that secondary electrons traversing the first cavity resonator are deflected in a first direction transversely oriented with respect to the beam path of the secondary electrons.
6. The electron microscopy system according to claim 5, wherein the position sensitive detector comprises a line detector having a plurality of electron sensitive regions disposed along a line.
7. The electron microscopy system according to claim 1, wherein the first cavity resonator and the high frequency generator are configured such that secondary electrons traversing the first cavity resonator are deflected in a first direction and a second direction, and wherein the first and second directions are transversely oriented with respect to each other and with respect to the beam path of the secondary electrons.
8. The electron microscopy system according to claim 7, wherein the position sensitive detector comprises an array of plural electron sensitive regions.

9. The electron microscopy system according to claim 1, wherein the energy selector comprises a beam splitter for separating the beam path of the secondary electrons from a beam path of the primary electron beam.
10. The electron microscopy system according to claim 1, further comprising an energy selector for separating beam paths of secondary electrons of different kinetic energies.
11. The electron microscopy system according to claim 10, wherein the energy selector comprises a beam splitter for separating the beam path of the secondary electrons from a beam path of the primary electron beam.
12. The electron microscopy system according to claim 10, wherein a separation direction of the energy filter with respect to the beam path of the secondary electrons is oriented transversely to a deflection direction of the first cavity resonator with respect to the beam path of the secondary electrons.
13. The electron microscopy system according to claim 1, wherein the objective lens is disposed in a beam path of the primary electron beam.
14. The electron microscopy system according to claim 13, wherein the objective lens comprises a beam deflector for scanning the primary electron beam across the sample.
15. The electron microscopy system according to claim 1, wherein the pulsed electron beam source comprises an

electron source, a second cavity resonator and a second beam stop having an aperture, wherein the second cavity resonator is disposed between the electron source and the second beam stop.

16. The electron microscopy system according to claim 15, wherein the first cavity resonator is disposed in a beam path of the primary electron beam wherein a deflection direction of the first cavity resonator with respect to the primary electron beam is oriented transversely to a deflection direction of the second cavity resonator with respect to the primary electron beam.
17. The electron microscopy system according to claim 1, wherein the pulsed electron beam source comprises an electron source, the first cavity resonator and a second beam stop having an aperture, wherein the first cavity resonator is disposed between the electron source and the second beam stop in a beam path of the primary electron beam.
18. The electron microscopy system according to claim 1, wherein the pulsed electron beam source comprises an electron emitting body and a pulsed photon source configured for emitting a pulsed photon beam incident on the electron emitting body.
19. An electron microscopy system, comprising:
  - a pulsed electron beam source for generating a pulsed primary electron beam incident on a sample;
  - an objective lens disposed in a beam path of secondary electrons emanating from the sample;

an electron detector disposed in a beam path of the secondary electrons downstream of the objective lens;

a first beam deflector for deflecting secondary electrons traversing the first beam deflector, wherein the first beam deflector is disposed in the beam path of the secondary electrons downstream of the objective lens and upstream of the electron detector; and

a high frequency generator for supplying a high frequency power to the first beam deflector to periodically change a deflection angle of the first beam deflector.

20. The electron microscopy system according to claim 19, wherein the first beam deflector comprises a cavity resonator to which the high frequency power is supplied.
21. The electron microscopy system according to claim 19, further comprising a controller configured to change a phase of the high frequency power supplied by the high frequency generator relative to a pulse generation cycle of the pulsed electron beam source.
22. An electron microscopy system, comprising:
  - a pulsed electron beam source for generating a pulsed primary electron beam incident on a sample;
  - an objective lens disposed in a beam path of secondary electrons emanating from the sample;
  - a time resolving electron detection system disposed in the beam path of the secondary electrons downstream of the objective lens, the time resolving electron

detection system having a time resolution of less than 100 pico seconds.

23. The electron microscopy system according to claim 22, wherein the time resolution is less than 50 ps.

24. A focusing system for charged particles, comprising:

a pulsed particle source for generating a pulsed beam of charged particles;

a focusing lens disposed in a beam path of the pulsed beam of charged particles;

a cavity resonator disposed in the beam path of the pulsed beam of charged particles upstream of the focusing lens; and

a high frequency generator supplying a high frequency power to the cavity resonator;

wherein the cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the cavity resonator is an oscillating electric field oriented in a direction of the beam path of the pulsed beam of charged particles traversing the cavity resonator, wherein an electric field strength of the oscillating electric field increases with an increasing distance from a center of the cavity resonator in a direction transverse to the beam path of the pulsed beam, and

wherein the pulsed particle source and the high frequency generator are synchronized such that, at a given time, one of the following conditions is fulfilled:

- charged particles of the pulsed beam traversing the cavity resonator gain an amount of energy which increases with an increasing distance from the center at which they traverse the cavity resonator, and
- the charged particles of the pulsed beam traversing the cavity resonator lose an amount of energy which decreases with an increasing distance from the center at which they traverse the cavity resonator.
25. The focusing system according to claim 24, wherein an excitation mode of the electromagnetic field in the cavity oscillator is substantially a  $TM_{010}$  mode.
26. A focusing system for charged particles, comprising:
- a pulsed particle source for generating a pulsed beam of charged particles;
- a focusing lens disposed in a beam path of the pulsed beam of charged particles;
- a cavity resonator disposed in the beam path of the pulsed beam of charged particles upstream of the focusing lens, wherein the cavity resonator and the focusing lens are disposed at a distance from each other to provide a drift region between the cavity resonator and the focusing lens; and
- a high frequency generator supplying a high frequency power to the cavity resonator;
- wherein the cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the cavity

resonator is an oscillating electric field oriented in a direction of the beam path of the pulsed beam of charged particles traversing the cavity resonator, and

wherein the pulsed particle source and the high frequency generator are synchronized such that charged particles of a bunch of particles of the pulsed beam traversing the cavity resonator and disposed in a rear portion of the bunch are accelerated as compared to charged particles disposed in a front portion of the bunch.

27. The focusing system according to claim 26, wherein an excitation mode of the electromagnetic field in the cavity oscillator is substantially a  $TM_{010}$  mode.
28. The focusing system according to claim 26, wherein the pulsed particle source and the high frequency generator are synchronized such that the bunch of charged particles enters the cavity oscillator when a field strength of the oscillating electric field is an increasing field strength.
29. The focusing system according to claim 26, wherein an oscillation period of the high frequency power is more than four times a time difference between a time when a front of the bunch enters the cavity resonator and a time when a rear of the bunch enters the cavity resonator.
30. The focusing system according to claim 26, wherein an oscillation period of the high frequency power is more than eight times a time difference between a time when a front of the bunch enters the cavity resonator and a time when a rear of the bunch enters the cavity resonator.

31. An electron microscopy system, comprising:

a pulsed electron beam source for generating a pulsed primary electron beam;

an objective lens for focusing the primary electron beam onto a sample;

a cavity resonator disposed in the beam path of the primary electron beam upstream of the objective lens; and

a high frequency generator supplying a high frequency power to the cavity resonator;

wherein the cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the cavity resonator is an oscillating electric field oriented in a direction of the beam path of the primary electron beam traversing the cavity resonator, wherein an electric field strength of the oscillating electric field increases with an increasing distance from a center of the cavity resonator in a direction transverse to the beam path of the pulsed beam, and

wherein the pulsed electron beam source and the high frequency generator are synchronized such that, at a given time, one of the following conditions is fulfilled:

electrons of the primary electron beam traversing the cavity resonator gain an amount of energy which increases with an increasing distance from the center at which they traverse the cavity resonator, and

the electrons of the primary electron beam traversing the cavity resonator lose an amount of energy which decreases with an increasing distance from the center at which they traverse the cavity resonator.

32. The electron microscopy system according to claim 31, wherein an excitation mode of the electromagnetic field in the cavity oscillator is substantially a  $TM_{010}$  mode.

33. An electron microscopy system, comprising:

a pulsed electron beam source for generating a pulsed primary electron beam;

an objective lens for focusing the primary electron beam onto a sample;

a cavity resonator disposed in the beam path of the primary electron beam upstream of the objective lens, wherein the cavity resonator and the objective lens are disposed at a distance from each other to provide a drift region between the cavity resonator and the objective lens; and

a high frequency generator supplying a high frequency power to the cavity resonator;

wherein the cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the cavity resonator is an oscillating electric field oriented in a direction of the beam path of the primary electron beam traversing the cavity resonator, wherein an electric field strength of the oscillating electric

field increases with an increasing distance from a center of the cavity resonator in a direction transverse to the beam path of the pulsed beam, and

wherein the cavity resonator and the high frequency generator are configured such that a main component of an electromagnetic field generated in the cavity resonator is an oscillating electric field oriented in a direction of the beam path of the pulsed beam of charged particles traversing the cavity resonator, and

wherein the pulsed particle source and the high frequency generator are synchronized such that charged particles of a bunch of particles of the pulsed beam traversing the cavity resonator and disposed in a rear portion of the bunch are accelerated as compared to charged particles disposed a front portion of the bunch.

34. The electron microscopy system according to claim 33, wherein an excitation mode of the electromagnetic field in the cavity oscillator is substantially a  $TM_{010}$  mode.
35. The electron microscopy system according to claim 33, wherein the pulsed particle source and the high frequency generator are synchronized such that the bunch of charged particles enters the cavity oscillator when a field strength of the oscillating electric field is an increasing field strength.
36. The electron microscopy system according to claim 33, wherein an oscillation period of the high frequency power is more than four times a time difference between a time when a front of the bunch enters the

cavity resonator and a time when a rear of the bunch enters the cavity resonator.

37. The electron microscopy system according to claim 33, wherein an oscillation period of the high frequency power is more than eight times a time difference between a time when a front of the bunch enters the cavity resonator and a time when a rear of the bunch enters the cavity resonator.
38. The electron microscopy system according to claim 33, wherein the objective lens comprises a beam deflector for scanning the primary electron beam across the sample.
39. An electron microscopy method, comprising:
  - generating bunches of primary electrons; accelerating a first group of primary electrons of each bunch of primary electrons relative to a second group of primary electrons of the bunch, using a cavity resonator supplied with a high frequency power; focusing the bunches in which the first group of primary electrons has been accelerated relative to the second group of primary electrons onto a sample; and detecting secondary electrons emanating from the sample.
40. The electron microscopy method according to claim 39, wherein electrons of the first group of primary electrons of the bunch are located radially outside of electrons of the second group of primary electrons of the bunch while the bunch is focused.

41. The electron microscopy method according to claim 39, wherein electrons of the first group of primary electrons of the bunch are located behind electrons of the second group of primary electrons of the bunch while the first group of primary electrons is accelerated relative to the second group.
42. An electron microscopy method, comprising:
  - generating bunches of primary electrons;
  - focusing the bunches of primary electrons onto a sample;
  - detecting a time structure of electron intensities of bunches of secondary electrons emanating from the sample.